

**Streamlined Engineering Evaluation and Cost Analysis
Morning Star Mine, Mojave National Preserve, California****EXECUTIVE SUMMARY**

The Morning Star Mine (MSM) is located within the Mojave National Preserve (MNP), approximately 75 miles south of Las Vegas, Nevada, 10 miles west of Ivanpah, and 12 miles west of Nipton, California (Fig. 1). The Morning Star Mine (Fig. 2) operated as a gold and silver underground mine during the 1930s and again from 1979 until 1992 as an underground and open pit, cyanide heap leach operation. Although no ore was being produced, some non-operational activities continued at the site until 1995. No further closure activities were conducted.

The mine was initially operated as an underground mine, producing high-grade ore that was processed off site. In 1984 the method of mining and processing was changed to an open pit onsite heap leach system. Components of the revised method of mining and processing included a lined heap leach pad (Pad No.1), which gravity drained to a separate, external lined pregnant solution pond, and a gold recovery facility that included carbon columns. The ore was chemically treated with a cyanide solution to dissolve gold and silver. The processing facility separated the precious metals from the solution, which was adjusted for chemical content and reapplied to the ore. The inventory of solution was constantly in circulation. A second heap leach pad (Pad No.2) constructed in 1989 was built with a modified solution storage and collection system integrated into the bottom of the pad (no gravity drain).

Leaching of Pad No. 1 ceased with the start-up of Pad No. 2 and efforts were made to rinse and close Pad No. 1. No known efforts were made to reduce the solution level in Pad No. 2, which rose with the addition of meteoric water after cessation of mining and processing operations at the site in 1992. At some point prior to 1998 solution began overtopping the Pad No. 2 liner (drainage flows were estimated at 0.5 to 2 gallons per minute (gpm)). In addition, the liner in the pregnant solution pond, which receives continuous flow from Pad No. 1, began showing signs of damage (cracking seams and tears from wind). Concerns were raised regarding the integrity of the pregnant solution pond liner, i.e., erosion from the overtopping solution resulting in failure of the steep slopes of the pads.

Meteoric water continued to add to the volume of solution contained within the two heap leach pads and pregnant solution pond (PSP) at the MSM site. In 1998, a release of cyanide-contaminated fluids was

documented; these fluids exceed California regulatory levels for Total and weak acid dissociable (WAD) cyanide. Early on, National Park Service personnel (NPS) recognized that the release of solution could be stopped quickly through temporary measures. Permanently stopping the overtopping of the liners and potential leakage from the pads and lined pond would require a much larger reclamation effort to remove the threat of solution releases. A Preliminary Assessment (PA) in accordance with a "non-time critical" removal action under CERCLA was performed to assess the threat posed to human health and the environment and to determine the need for additional action. The results of the PA concluded that additional site investigation was warranted. Additional sampling events were performed in 1998, 1999, 2000, 2001, and 2002. Total cyanide concentrations have ranged from non-detect to 8.9 mg/l; Weak Acid Dissociable (WAD) cyanide values ranged from non-detect to 2.1 mg/l at surface water sampling sites within the mine area (Table 3.1).

The Code of Federal Regulations (40 C.F.R. § 300.415(b)(4)) states that if on-site removal activities do not have been initiated for at least six months, the lead agency must conduct an Engineering Evaluation/Cost Analysis (EE/CA) or its equivalent to evaluate removal alternatives prior to initiating the action. As such, the NPS is in the process of preparing to conduct a "non-time critical" removal action under CERCLA, 42 U.S.C. § 9604(a) to respond to the threat of potentially catastrophic releases from the two heap leach pads and pregnant solution pond (PSP). To address the release of cyanide solution, Interim Measures were initiated to stop the release of cyanide to the environment until final site closure is complete. The Interim Measures were constructed in the summer of 2002 and included re-lining the PSP and installing an active evaporation system (Section 9.0) to reduce the solution inventory of the two heap leach pads and the PSP. The EE/CA prepared by Harding ESE, Inc. for the NPS, Mojave National Preserve (Fig.1), is in accordance with Contract Number 1443-CX-2605-98-002.

During installation of the Interim Measures, additional water samples were collected from areas of concern at the site. These included the bottom of the open pit, Pad No.1, the pregnant solution pond, the leak detection system for the pregnant solution pond, the leachate collection system and leak detection system from Pad No. 2, and standing water on the perimeter of Pad No. 2. Analyses confirmed (Table ES.1) that contaminants of concern in water from the vicinity of the two pads and the leachate contained within the pads exceeded discharge limits established by the Lahontan Regional Water Quality Control Board (LRWQCB). The contaminants of concern included Total cyanide and Weak Acid Dissociable (WAD) cyanide. The California MCL, measured in milligrams per liter (mg/l), for Total cyanide is 0.20 mg/l; the LRWQCB limit for Total cyanide is 1.0 mg/l and 0.2 mg/l for WAD cyanide.

- Water sample analysis indicated the level of Total cyanide has been as high as 7.29 mg/l in the leachate from Pad No. 1. The level of WAD cyanide has been as high as 1.0 mg/l in standing water on the west side of Pad No. 2. Both values exceed discharge limits.
- Soil samples were also obtained from the two heap leach pads, the waste rock dump and downgradient of Pad No.1. Total and WAD cyanide were detected on the south side of Pad No. 2; however, the concentration level did not exceed regulatory limits. Other soil sample analyses indicated the metals barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, vanadium and zinc were present; however, only the concentration for lead (1160 mg/kg) exceeded the California Total Threshold Limit Concentration of 1000 mg/kg.

Table ES.1. Total and Weak Acid Dissociable (WAD) Cyanide Levels in Surface Water at Selected Locations, Morning Star Mine Site, 1998 – 2002.

Location	Sample Date	Total CN mg/l	WAD CN mg/l
Mine Pit	Dec-98	nd	-
	Dec-98(D)	nd	-
	Mar-00	nd	-
	Jul-02	nd	nd
Heap Leach Pad 1 Discharge	Dec-98	2.20	-
	Feb-99	7.00	1.30
	Mar-00	7.29	1.54
	May-01	8.9	0.08
Pregnant Solution Pond	Dec-98	nd	-
	Feb-99	-	1.00
	Mar-00	nd	- ¹
	May-01	nd	0.48
	Jul-02	1.16	0.24
Heap Leach Pad 2 Leachate Collection System	Dec-98	-	0.34
	Feb-99	0.22	0.25
	Mar-00	0.12	0.19
	May-01	0.140	nd
	Jul-02	0.010	nd
Regulatory	California MCL	0.20	--
Limits	LRWQCB	1	0.2

Table ES.1. Total and Weak Acid Dissociable (WAD) Cyanide Levels in Surface Water at Selected Locations, Morning Star Mine Site, 1998 – 2002, continued.

	Sample Date	Total CN mg/l	WAD CN mg/l
Standing Water Pad 2 - Southwest	Dec-98	1.1	-
	Feb-99	1.8	0.9
	Mar-00	1.8	1.0
	Mar-00(D)	1.0	0.5
	Mar-00(D)	-	-
	May-01	2.0	0.4
	Jul-02*	-	-
Standing Water Pad 2 - Southeast	Dec-98	0.7	0.7
	Feb-99	1.6	0.9
	Mar-00	1.0	0.6
	Mar-00	-	-
	May-01	0.8	nd
	Jul-02*	-	-
Regulatory Limits	California MCL	0.20	--
	LRWQCB	1	0.2

*Sampling in July 02 took place after initiation of the Interim Measures. Both leaks had dried up.

A streamlined risk evaluation based on regional and site data and available sampling information indicated that Total cyanide, WAD cyanide, cadmium, chromium, cobalt, copper, lead, molybdenum, selenium, and thallium concentrations may be of concern to human health. The risk analysis also indicated that Total cyanide, WAD cyanide, cadmium, chromium, copper, lead, mercury, molybdenum, selenium, and thallium concentrations may be of concern to ecological receptors. As such, an ecological survey may be needed to determine the species most likely to be exposed to site media as well as the presence of any special-status species within the site area. Identification of potential utilization of the site by ecological receptors (i.e., nesting versus foraging) may assist to determine ecological risk. Risk analysis for both human health and ecological receptors may require additional data to evaluate the form of some chemicals present (e.g., chromium III versus chromium VI) as well as the bioavailability/leachability of metals in site media. Also, site-specific background levels of metals in soil and/or surface water could be useful in the selection of chemicals of potential concern (COPC's) and in differentiating between site-related and non-site-related risks. Additional sampling may be needed, including analysis of soil from ephemeral drainages to the southeast and southwest of the mine facilities. However, the laboratory detection limits for analysis have been lowered in order to provide a more definitive comparison to background levels.

In addition to evaluating the human and ecological risk presented by the site, the EE/CA examines the regulatory framework of federal and state requirements that need to be considered during the evaluation of alternatives. Under CERCLA, the regulatory examination describes applicable or relevant and appropriate requirements (ARARs) that must be attained to the extent practicable. An “applicable” requirement is a cleanup standard, standard of control or other environmental protection requirement promulgated under federal or state law that specifically addresses a hazardous substance, pollutant, contaminant, remedial action, location or circumstance at a CERCLA site. A “relevant and appropriate” requirement is similar to an applicable requirement. Although not “applicable” to the situation it is sufficiently similar that its use is well suited to the particular site’s circumstances. The purpose of the remedy selection process is to implement remedies that eliminate, reduce, or control risks to human health and the environment (40 CFR § 300.4).

The evaluation of pertinent regulatory issues was performed to identify a regulatory framework for developing and evaluating alternative remedial actions appropriate for the site. The development of alternatives was “streamlined” in that the EE/CA was specifically focused on only three mine site components – the two heap leach pads and the pregnant solution pond. The development of alternatives was limited to closure of these three elements of the mine.

Five alternatives were developed for closure of the two heap leach pads and the pregnant solution pond. The closure alternatives evaluated included the No Action Alternative, Closure of the Heap Leach Pads in Place, Clean Closure of the Heap Leach Pads in Place (with an option for construction of a repository in the pit), and Off-site Removal to an approved landfill. The 4EM Company remedial proposal was presented as a fifth alternative. The alternatives were compared on the basis of effectiveness, implementability and cost in accordance with EPA guidance (Table ES.2). Due to the risk of continued loss of cyanide to the environment from the two heap leach pads and the pregnant solution pond, Interim Measures were implemented to evaporate excess solution from the containment capacity of the pads and PSP. A remedial action proposal developed by the 4EM Company to reuse pad materials as pozzolan, a concrete additive, was submitted to the MNP and has been described as an off-site closure alternative. No attempt to critically analyze the 4EM proposal has been made in this document. If the 4EM proposal is selected as the Preferred Alternative, a separate environmental impact analysis would be prepared to evaluate the operation and the environmental and engineering information required for the applicable permits required.

The preferred alternative has not been selected at this time (Table ES.3). The selection process will be conducted following MNP review, EPA and LRWQCB review, and a final review of all ARARs. The preferred alternative selection by these agencies is an extremely important aspect of finalizing the EE/CA and all factors leading to that selection will be carefully examined. Once the preferred alternative decision is made, the draft EE/CA document will be distributed for public comment. The response to public comments will be reflected in the final EE/CA document.

Table ES.2 Summary of Remedial Alternatives

Criteria	Alternative 1 Interim Measures, No Action	Alternative 2 Interim Measures, Close Heap Leach Pads in Place	Alternative 3 Interim Measures, Clean Close Heap Leach Pads in Place, Alternative 3a – Pit Repository	Alternative 4 Interim Measures, Off-Site Removal, Haul to Landfill	Alternative 5 The 4EM Proposal
Overall Protection of Human Health and the Environment	No. Not protective. Exposure and offsite release potential to contaminants would remain.	Yes. Reduction of solution inventory. Draw down and evaporate solution in Pad No. 2. Cap pads with low permeability cover, manage drain down 5 yrs post capping, reclaim PSP.	Yes. Reduction of solution inventory. Treat pads in place with bioremediation treatment to comply with discharge criteria. Shaping heap leach pads and capping with low permeability capping system. 5 yrs water management post capping, reclaim PSP. Alternative 3a - haul pad material to open pit for disposal after treatment. Secondary treatment applied as pad material deposited in pit. Reduce solution inventory. Immobilize metals, detoxify cyanide and nitrates.	Yes. Reduction of solution inventory. Contents of pads and ponds hauled to licensed solid waste landfill. Pad and PSP disturbance footprints reclaimed.	Yes. Reduction of solution inventory. Contents of pads utilized as concrete additive and hauled from site. Pad and PSP disturbance footprints reclaimed. Additional specific detail needed regarding method and timeframe to achieve waste discharge requirements.
Compliance with ARARs	No. Does not comply with ARARs	Closure of the pads in place would be technically and administratively feasible. Contract services and material vendors are available within region. Community acceptance will reflect public comments on EE/CA document.	Closure of the pads in place would be technically and administratively feasible as would the construction of a repository in the pit. Contract services and material vendors are available within region. Community acceptance will reflect public comments on EE/CA document.	Yes. Complies with ARARs. Mitigation measures for listed species to be negotiated.	Compliance with ARARs to be negotiated with DOI/NPS regarding 36 CFR Ch. 1, Part 6 requirements and mitigation measures for listed species.
Long-term Effectiveness and Permanence	No. Not effective at minimizing risks.	Yes. Solution reduction through evaporation and low permeability cap to provide long-term protection as long as integrity of caps maintained.	Yes. Solution reduction through evaporation. Solution toxicity neutralized through bioremediation. Secondary bioremediation treatment of pad material as placed in pit and low permeability cap to provide long-term protection as long as integrity of cap maintained.	Effective. Solution reduction through evaporation. Constituents of concern removed to approved landfill for permanent disposal. Disturbance footprints reclaimed at site.	Effective. Solution reduction through evaporation. Constituents of concern removed by creation of finished product. Shipment of product removes it from the site for distribution. Disturbance footprints reclaimed at site.
Reduction of Toxicity, Mobility or Volume through Treatment	No treatment provided	Yes. Solution volume reduced through evaporation. Addition of meteoric water reduced through capping system.	Yes. Solution volume reduced through evaporation. Addition of meteoric water reduced through capping system. Bioremediation treatment of the pads in place and, with Alternative 3a, as material is placed in pit.	Yes. Potentially toxic materials would be hauled from the site to licensed solid waste landfill.	Additional specific detail needed regarding method and timeframe to achieve waste discharge requirements. Solution volume reduced through evaporation. Reduction of cyanide levels in Pad No. 2.

Short-term Effectiveness	Yes. Implementation of Interim Measures may impede release for unknown length of time; however, meteoric water would continue to be added to volume. Risk from catastrophic slope failure would continue to increase.	Yes. Implementation of Interim Measure to provide solution reduction for short term. Installation of infiltration reduction cap to significantly reduce volume of future increase due to meteoric water.	Yes. Implementation of Interim Measure to provide solution reduction for short term. Installation of infiltration reduction cap to significantly reduce volume of future increase due to meteoric water.	Yes. Implementation of Interim Measure to provide solution reduction for short term. Potentially toxic materials would be hauled from the site.	Yes. Implementation of water management to provide solution reduction for short term. Potentially toxic materials would be hauled from the site. Additional details regarding safeguards to human health and the environment from potentially harmful pad and solution constituents.
Implementability	N/A. Only Interim Measure would be implemented. Not intended to be considered as a removal alternative. Interim measures are technically and administratively feasible. Contract services and material vendors are available within region. Community acceptance will reflect public comments on EE/CA document.	Closure of the pads in place would be technically and administratively feasible. Contract services and material vendors are available within region. Community acceptance will reflect public comments on EE/CA document.	Clean closure of the pads in place would be technically and administratively feasible. Contract services and material vendors are available within region. Community acceptance will reflect public comments on EE/CA document.	Yes. However, pumping and evaporating solution inventory could take two to several years. Cost is probably prohibitive.	Implementability to be negotiated with DOI/NPS regarding compliance with 36 CFR Ch. 1, Part 6 and mitigation measures for listed species. Pumping and evaporating solution inventory could take two to several years. Work plan schedule for use of pads and PSP areas is 10 years. Cost for reclamation of remainder of MSM site to be covered by escrow fund. Total at end of operation - \$1,000,000
Cost	Cost to implement Interim Measure plus 30 years of inspection and maintenance. \$505,754	Draw down and evaporate solution in Pad No. 2, regrade and cap heaps with low permeability cap, 5 yrs water management, reclaim PSP \$2,625,956	Rinse and evaporate solution inventory, bioremediation treatment, regrade and cap heaps with low permeability cap, 5 yrs water management, reclaim PSP \$2,914,809 Option – Alternative 3a – pit repository, Backfill pit with waste rock to 10 feet above water elevation, haul pad material after rinsing and bioremediation in place, second treatment as placed in pit, low permeability cap on material in pit, reclaim heap foot prints, revegetate pad and pit areas, reclaim PSP \$4,977,694	Draw down and evaporate solution in Pad No. 2, load and haul pad material to approved landfill. Reclaim pad and PSP footprints. \$150,421,016	The construction cost of the 4EM proposal has not been disclosed. MNP has the statutory authority to impose a construction bond and a fee per ton per mile within park boundaries to offset potential damage to roads. Additional verification and monitoring data would be required from 4EM regarding off site transportation and use. A separate environmental analysis of the 4EM proposal would be required prior to startup and all pertinent permits obtained. Revenue estimate from 4EM \$1,000,000

TABLE ES.3
SUMMARY OF ALTERNATIVE ACTIONS

ALTERNATIVE 1 - NO ACTION	TOTAL COST	\$505,754
A. Inspections & Maintenance		
ALTERNATIVE 2 - CLOSE HEAP LEACH PADS IN PLACE	TOTAL COST	\$2,625,956
A. Design, Management, Mobilization, Site Support		
B. Draw Down and Evaporate Solution In Heap Leach Pad No.2		
C. Regrade Heaps to 3:1		
D. Cap and Reclaim Heap Leach Pads		
E. Inspections & Maintenance		
F. Water Management (5 years after cap)		
G. Reclaim Pregnant Solution Pond (5 years after drawdown and cap)		
ALTERNATIVE 3 - CLEAN CLOSE HEAP LEACH PADS IN PLACE	TOTAL COST	\$2,914,809
A. Design, Management, Mobilization, Site Support		
B. Rinsing / Active Evaporation Systems on Heap Leach Pads		
C. Bioremediation Treatment System		
D. Regrade Heaps to 3:1		
E. Cap and Reclaim Heap Leach Pads		
F. Water Management (5 years after cap)		
G. Reclaim Pregnant Solution Pond		
OPTION TO ALTERNATIVE 3 - CLEAN CLOSURE HEAP LEACH PADS TO PIT REPOSITORY	TOTAL COST	\$4,977,694
A. Design, Management, Mobilization, Site Support		
B. Rinsing / Active Evaporation Systems on Heap Leach Pads		
C. Bioremediation Treatment System		
Option: Haul Pad Material to Pit (Do Not Reclaim Pads in Place)		
1. Detailed Design		
2. Load, Haul and Place Waste Rock in Pit		
3. Load, Haul and Place Heap Material in Pit		
4. Final Bioremediation Treatment		
5. Shape and Compact Surface		
6. Place Cap		
7. Place Drain Layer		
8. Place Remaining Waste Rock		
9. Place Media Growth Layer		
10. Perimeter Drain		
11. Reclaim Heap Footprints		
12. Revegetate Pad and Pit Areas		
13. Reclaim Pregnant Solution Pond		
ALTERNATIVE 4 - OFF-SITE REMOVAL (LANDFILL)	TOTAL COST	\$150,421,016
A. Design, Management, Mobilization, Site Support		
B. Draw Down and Evaporate Solution In Heap Leach Pad No.2		
C. Load and Haul Heap Leach Material		
D. Water Management		
E. Pad and Pond Reclamation		
ALTERNATIVE 5 - OFF-SITE REMOVAL (4EM PROPOSAL)	EXPECTED REVENUE	\$1,000,000
A: Crush, Process and Haul All Heap Pad Material Product to be sold as a cement additive.		